UNIVERSITY DEPARTMENT OF ZOOLOGY

RANCHI UNIVERSITY, RANCHI

Synopsis for Ph.D.

Studies on the Effects of Green-Synthesized Nanoparticle Antifeedant Formulations on *Spodoptera frugiperda* (Smith, 1797) (Lepidoptera: Noctuidae) and Potential for Pest Management

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TOPIC: -

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1. STATE OF THE ART

The most varied group of animals on the planet is insects (Dhaliwal (2015). Lepidoptera is the second largest and most diverse order in the class Insecta, which includes more than half of all known animal species worldwide (Tihelka *et al*., (2021). Over 100,000 species of lepidopterans insects have been investigated to date. Insects harm plants directly or indirectly as they seek food, attacking and damaging nearly every part of the plant, including the roots, stem, bark, shoot, leaves, bud, flower, and fruits (Ruiz-Aguilar (2025). In agriculture, insects have a direct impact on the crop's growing stage, causing significant harm and financial loss (Kumar *et al*., (2020). For major crops, the anticipated crop loss from insect pests ranges from 10% to 30% (Arivoli *et al.,* (2013). Global use of pesticides has continued to grow over the last few decades, Farmers rely on synthetic insecticides to control insect pests, even though the use of pesticides has demonstrated a genuine influence on environmental and human health issues. Overuse of pesticides has serious negative effects on food safety by reducing beneficial insects in production regions, generating environmental pollution, allowing secondary pests to appear, and making target arthropods resistant. The search for alternative insect pest control is becoming increasingly important and includes the use of plant-derived pesticides. Plant-derived pesticides are reported as effective in controlling various insect pests through natural mechanisms, with biodegradable organic materials, diverse bioactivity, and low toxicity to non-target organisms.

A number of pest control methods are used in integrated pest management (IPM) with the goal of reducing or eliminating the need for synthetic pesticides entirely. For modern material science researchers, one of the most important fields is nanotechnology. Interest in nanobiotechnology these days is the development of environmentally friendly technology for the production of metal/metal oxide nanoparticles with astonishing and indefinite uses in the domains of food, medicine, defense, cosmetics, agriculture, and environmental safety (Melanie *et al*., (2022).

The advantages of a nanotechnology-based formulation for antifeedants provide an alternative to prevent the negative impact of synthetic insecticides that may cause pest resistance. Antifeedant active ingredients cause starvation rather than immediate pest death. Thus, new innovative approaches are needed to ensure the effectiveness of antifeedant deployment in the field under varied environmental conditions. Nanoparticles are showing promise in different fields of agricultural Biotechnology. The use of nanomaterials in agriculture, especially for plant protection and production, is an under-explored research area, Many countries are now switching over from chemical-based agriculture to green agriculture, where the utilization of biopesticides and also biological nanomaterials have a lot of role to play in pest control (Kitherian 2017).To manage crop pests, a range of metal nanoparticles, including silver (Ag), gold (Au), aluminum (Al), silica (Si), and zinc (Zn), as well as metal oxide-based polymers, such as zinc oxide (ZnO) and titanium dioxide (TiO_2), are being produced (Pittarate *et al*.,(2021).

In a recent significant review of antifeedant strategies involving the role of nanotechnology approaches and opportunities, (Koul 2016) assessed that, because of the laboratory scale of plant extract screening, most antifeedant studies still rely on an investigation of the antifeedant's source as being from a variety of essential oils and crude plant extracts, including their bioassays Hence, a nano-based formulation to achieve desirable properties is required in antifeedant

application strategies. However, there has been relatively little research conducted in the areas of nanomaterials and pest management, and many more are expected in the future.

2. PROBLEMS TO BE INVESTIGATED-

1. Effects of Nanoparticles (NPs)-based Antifeedant on developmental stages of *S. frugiperda* (Smith, 1797).
2. Effects of NPs Antifeedant on mortality rates.

3. OBJECTIVES

a. To study the effect of NPs Antifeedant of taken plant samples on different life stages (Eggs, Larvae, Pupa, and Adults).

b. To study the behavioral approaches and resistance towards nanoparticle-based antifeedants.

c. Assess NPs Antifeedant effects on reproductive success, and mortality rate of the insect.

d. To evaluate the impact of a mixture of various concentrations of NP antifeedants of taken plant samples on *S. frugiperda*.

4. MOTIVATION

Conventional insecticides often harm the environment and non-target organisms, Nanoparticles improve the solubility and dispersion of antifeedant compounds, increasing their effectiveness against insects. They enable controlled and targeted delivery, ensuring prolonged action. Antifeedants offer a sustainable less toxic approach to pest management and studying plant-derived antifeedants can lead to the development of new bio-insecticides and can be integrated into Integrated Pest Management programs to reduce dependency on chemical pesticides and provide a novel and sustainable approach for agricultural pest control.

5. HYPOTHESIS

Insects are major pests that cause significant agricultural losses by feeding on crops, leading to reduced yield and quality. Conventional chemical pesticides often pose environmental risks and contribute to insect resistance. Nanoparticle-based antifeedants effectively deter insect pests by enhancing the bioavailability, stability, and controlled release of bioactive compounds, leading to reduced crop damage and lower environmental impact compared to conventional methods.

6. RESEARCH DESIGN AND METHODOLOGY

6.1 COLLECTION AND PROCESSING OF PLANT MATERIALS (*Cinnamomum tamala*, *Nerium oleander*, etc.)

1. Fresh plant material will be collected from a selected location and will be identified for authenticity.
2. The plant samples will be washed thoroughly with distilled water to remove dirt and contaminants.
3. The cleaned plant material will be shade-dried at room temperature for several days.
4. Once dried, the material will be ground into a fine powder using a mechanical grinder.

6.2 GREEN SYNTHESIS OF NANOPARTICLES. (Nahar *et al.*, 2019, Rosman *et al*., 2020, Devi *et al*., 2019 and Ajitha *et al*., 2015)

1. Extraction of crude plant extracts and phytochemical screening as per the methods of following references

(Bharadwaj *et al*., (2022) Mishra *et al*., (2010), Phukan (2017) Tandukar *et al*., (2022) and Çilesizoğlu *et al*., (2022).

2. Preparation of Plant Extract for nanoparticle synthesis:

Aqueous Extraction:

- Powdered plant material will be boiled in distilled water (ratio1:10) for 10–30 minutes.
- The extract will be cooled, filtered using Whatman No.1 filter paper, and stored at 4°C for further use.

3. Preparation of Metal Salt Solution:

- A precursor salt solution silver nitrate ($AgNO_3$) for silver nanoparticles, will be prepared in distilled water.
- The concentration of the metal salt solution will be optimized based on desired nanoparticle properties.

4. Nanoparticle Synthesis Process:

- The plant extract will be added dropwise to the metal salt solution under constant stirring at room temperature.
- The reaction mixture will be stirred for 1–6 hours until a visible colour change indicates nanoparticle formation.

5. Purification of Nanoparticles:

- The synthesized nanoparticles will be centrifuged at 10,000–15,000 rpm for 15–30 minutes to separate them from the reaction medium.
- The collected nanoparticle pellet will be washed multiple times with distilled water or ethanol to remove impurities.
- The purified nanoparticles will be dried at 50–80°C in a hot air oven

Some other relevant procedures may be adopted as per the need of the project.

6.3 CHARACTERIZATION OF NANOPARTICLES

UV-Vis Spectroscopy: The absorbance spectrum of nanoparticles will be recorded to confirm their synthesis.

6.4 EVALUATION OF ANTIFEEDANT ACTIVITY

1. Test Insect Selection:

   Spodoptera frugiperda larvae will be selected for testing.

2. Leaf-Dip Bioassay:

   Fresh leaves will be dipped in nanoparticle suspension and dried.

   Treated leaves will be placed in petri dishes with test insects.

   The feeding preference and leaf damage will be recorded over a specific period.

3. No-Choice and Dual-Choice Assay:

   Insects will be offered treated vs. untreated leaves.

   The amount of leaf area consumed will be measured to determine repellency and deterrence.

4. Mortality and Growth Effects:

   Insect survival, weight change, and behavioral alterations will be monitored after nanoparticle exposure.

The mortality in percent will be determined by the following formula (Francisco 2014):

$$\% \text{ M} = \frac{Lv}{Po} \times 100$$

In which:

% M = Percentage of larval mortality

Po = Initial Population

Lv = Dead larvae per treatment

6.5 STATISTICAL ANALYSIS

- Data will be analyzed using ANOVA to determine significance.
- Results will be presented in graphs or tables to compare the antifeedant effect of nanoparticle pellets vs. nanoparticle suspension.

6.6 DATA ANALYSIS

Data analysis will be done with the help of Microsoft Excel, SPSS software, and other software so that accurate results can be obtained and analyzed.

6.7 INTREGATION OF AI

Integration of a few AI techniques for various purposes in this research project like: e-butterfly AI, etc.

7. SIGNIFICANCE OF THE STUDY

1. The research will contribute to the development of plant-derived nanoparticle formulations as safe and biodegradable alternatives to synthetic pesticides. This approach will help reduce pesticide residues in food and the environment.
2. By promoting the use of plant-based nanomaterials, this research will support sustainable and organic farming.
3. The study will provide new insights into integrating nanoparticle-based antifeedants into IPM programs.
4. The research will expand the application of nanotechnology in crop protection and insect behaviour modification. Findings will contribute to scientific knowledge and future innovations in nanobiotechnology.

8. PATENT PLAN

As per IPR norms, if conceptualized during the work.

9. FUTURE ASPECTS-

1. Nanoparticle-based antifeedants will play a crucial role in revolutionizing pest management strategies by offering a sustainable and eco-friendly alternative to conventional chemical pesticides.

2. Unlike synthetic pesticides, plant-based nanoparticle formulations will have selective toxicity towards pests while being safer for pollinators, beneficial insects, and humans.

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